(19)日本国特許庁（ＪＰ）　(12)公開特許公報（Ａ）　(11)特許出願公開番号
特開2000－164104
（P2000－164104A）
(43)公開日　平成12年６月16日(2000.6.16)

(51)Int.Cl.⁷	識別記号	ＦＩ	ﾃｰﾏｺｰﾄﾞ(参考)
Ｈ０１Ｈ　59/00		Ｈ０１Ｈ　59/00	

審査請求　未請求　請求項の数４　ＯＬ　（全７頁）

(21)出願番号　特願平10－335725

(22)出願日　平成10年11月26日(1998.11.26)

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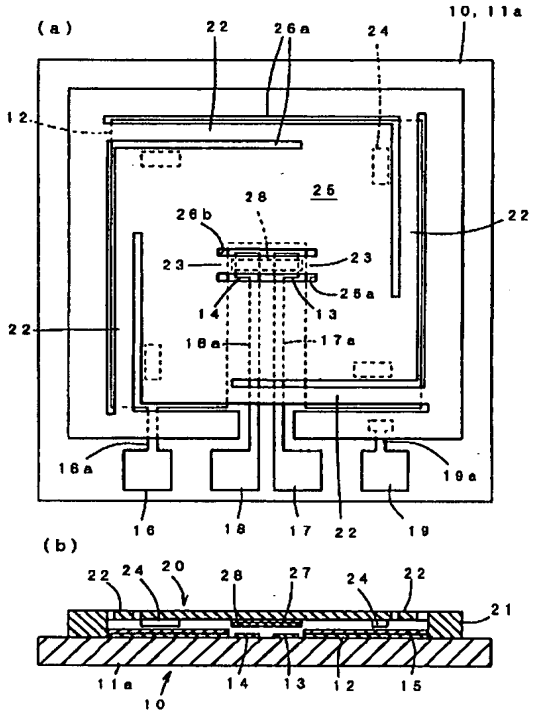
(54)【発明の名称】　静電マイクロリレー

(57)【要約】
【課題】　簡単な構造で、大型化を招くことなく、安価で簡単に製作できる接点開離性に優れた静電マイクロリレーを提供する。
【解決手段】　固定基板１０又は可動基板２０の少なくともいずれか一方に、可動基板２０の駆動後、接点閉成前に、残る他方の基板２０又は１０に当接する凸部２４を形成する。



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【特許請求の範囲】

【請求項１】　固定基板に支持部を介して可動基板を所定間隔で対向配設し、固定基板の固定電極と可動基板の可動電極との間に電圧を印加し、静電引力を発生させて可動基板を駆動することにより、可動基板の可動接点を固定基板の固定接点に閉成する静電マイクロリレーにおいて、

前記両基板のうち、少なくともいずれか一方に凸部を形成し、可動基板の駆動後、接点閉成前に、前記凸部が残る他方の基板に当接するようにしたことを特徴とする静電マイクロリレー。

【請求項２】　前記凸部は、前記支持部と接点の間の少なくとも１箇所に設けたことを特徴とする請求項１に記載の静電マイクロリレー。

【請求項３】　前記凸部は、該凸部を設けた基板とは反対側の基板に当接した際、そのとき電極間に生じる静電引力により、前記凸部の近傍で可動基板を弾性変形させて接点を閉成可能とする寸法以下の高さであることを特徴とする請求項１又は２に記載の静電マイクロリレー。

【請求項４】　前記可動基板を支持部から延びる複数の梁部を介して均等に支持すると共に、前記凸部を各梁部に対応して均等に設けたことを特徴とする請求項１ないし３のいずれか１項に記載の静電マイクロリレー。

【発明の詳細な説明】

【０００１】

【発明の属する技術分野】本発明は、静電マイクロリレーに関するものである。

【０００２】

【従来の技術】従来、静電マイクロリレーとして図８に示す構成のものがある（特開平５－２９７６号公報参照）。

【０００３】この静電マイクロリレーでは、固定基板１００の上面に設けた枠状の支持部１０１の内側に可動基板１０２が弾性支持され、固定基板１００の上面に形成した固定電極１０３と、可動基板１０２の下面に形成した可動電極１０４とが対向している。そして、前記両電極１０３，１０４間に電圧を印加して静電引力を発生させ、可動電極１０４を固定電極１０３に吸引することにより、可動基板１０２を撓ませて可動接点１０５を固定接点１０６に閉成するようになっている。

【０００４】

【発明が解決しようとする課題】しかしながら、前記静電マイクロリレーでは、接点閉成時、粘着や溶着等が発生するため、確実に接点を開離できるように、弾性復帰力を大きくしなければならない。このため、両電極間に発生させる静電引力を増大させる必要が生じ、駆動電圧（電極間に印加する電圧）や対向する電極面積を大きくしたり、電極の間隙寸法を小さくしたり、あるいは、エレクトレットを用いる等により対処しなければならない。この結果、占有体積の増大、接点耐圧の低下、構造及び加工工程の複雑化、及び、コストアップを招来していた。

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【０００５】そこで、本発明は、簡単な構造で、大型化を招くことなく、安価で簡単に製作できる接点開離性に優れた静電マイクロリレーを提供することを課題とする。

【０００６】

【課題を解決するための手段】本発明は、前記課題を解決するための手段として、固定基板に支持部を介して可動基板を所定間隔で対向配設し、固定基板の固定電極と可動基板の可動電極との間に電圧を印加し、静電引力を発生させて可動基板を駆動することにより、可動基板の可動接点を固定基板の固定接点に閉成する静電マイクロリレーにおいて、前記両基板のうち、少なくともいずれか一方に凸部を形成し、可動基板の駆動後、接点閉成前に、前記凸部を残る他方の基板に当接するようにしたものである。

【０００７】この構成により、両電極間に電圧を印加して静電引力を発生させると、可動基板は、その支持部から延びる部分が全体的に弾性変形し、いずれか一方の基板に設けた凸部が、残る他方の基板に当接する。これにより、可動電極が固定電極に接近し、静電引力は増加する。したがって、可動基板は、凸部の近傍で部分的に弾性変形し、可動電極が固定電極に吸着されるので、可動接点が固定接点に閉成する。

【０００８】その後、両電極間の印加電圧を除去すると、静電引力が消失し、支持部から延びる部分全体の撓みにより発生した弾性力のみならず、凸部が基板に当接することにより発生した部分的な変形に伴う弾性力が、接点開離力として作用する。そして、凸部が基板から離間すれば、可動基板は全体の撓みにより発生した弾性力によって元の対向位置に復帰する。

【０００９】前記凸部は、前記支持部と可動接点の間の少なくとも１箇所に設ければよい。

【００１０】前記凸部は、該凸部を設けた基板とは反対側の基板に当接した際、そのとき電極間に生じる静電引力により、前記凸部の近傍で可動基板を弾性変形させて接点を閉成可能とする寸法以下の高さとすればよい。例えば、凸部が基板に当接した時点での電極間距離が、離間した基板間隔の１／３以下となるように凸部の高さを決定すればよい。これにより、接点開離力を増大させるために設けた凸部の存在によって接点の閉成動作に支障を来すことはない。

【００１１】前記可動基板を支持部から延びる複数の梁部を介して均等に支持すると共に、前記凸部を各梁部に対応して均等に設けると、可動基板を、凸部が基板に当接する前後のいずれでもスムーズに動作させることができる点で好ましい。

【００１２】

【発明の実施の形態】以下、本発明に係る実施形態を添

付図面に従って説明する。

【００１３】図１及び図２は、本実施形態に係る静電マイクロリレーを示す。この静電マイクロリレーは、ガラス基板１１ａからなる固定基板１０の上面に可動基板２０を設けたものである。

【００１４】前記固定基板１０には、ガラス基板１１ａの上面に固定電極１２及び固定接点１３，１４が形成されている。固定電極１２の表面は絶縁膜１５で被覆されている。前記固定電極１２及び固定接点１３，１４は、プリント配線１６ａ及び１７ａ，１８ａを介して接続パッド１６及び１７，１８にそれぞれ接続されている。

【００１５】また、前記可動基板２０は、前記ベース１０の上面に設けた支持部２１の上面縁部から側方に延在する４本の第１梁部２２に可動電極２５を均等に支持したものである。第１梁部２２と可動電極２５の接続部分下面には凸部２４がそれぞれ形成されている。そして、静電引力により可動基板２０が撓むと、接点が閉成する前に、必ず凸部２４が固定基板１０に当接するようになっている。また、凸部２４は、固定基板１０への当接時、両電極１２，２５の距離が、離間した固定基板１０と可動基板２０の間隔の１／３以下となるように形成されている。これにより、凸部２４が固定基板１０に当接した時点で、静電引力が急激に大きくなり、凸部２４の存在に拘わらず、確実に固定電極１２に可動電極２５を吸着させることが可能となっている。

【００１６】なお、前記凸部２４は、可動基板２０に設けるようにしたが、固定基板１０側に設けたり、両基板１０，２０に設けるようにしてもよい。また、前記凸部２４は、接点１３，１４，２８と支持部２１の間に、２箇所以上設けるようにしてもよい。

【００１７】前記支持部２１は、固定基板１０の上面に設けたプリント配線１９ａを介して接続パッド１９に接続されている。前記可動電極２５には、その中央に一対のスリット２６ｂ，２６ｃにより第２梁部２３が形成されている。第２梁部２３の下面中央には絶縁膜２７を介して可動接点２８が設けられている。可動接点２８は前記固定接点１３，１４に接離可能に対向している。

【００１８】続いて、前記構成からなる静電マイクロリレーの製造方法を説明する。

【００１９】まず、図３（ａ）に示すパイレックス等のガラス基板１１ａに図３（ｂ）に示すように固定電極１２、固定接点１３，１４を形成する。また同時に、プリント配線１６ａ，１７ａ，１８ａ，１９ａ、及び、接続パッド１６，１７，１８，１９をそれぞれ形成する。そして、前記固定電極１２に絶縁膜１５を形成することにより、図３（ｃ）に示すベース１０が完成する。

【００２０】なお、前記絶縁膜１５として比誘電率３～４のシリコン酸化膜あるいは比誘電率７～８のシリコン窒化膜を用いれば、大きな静電引力が得られ、接触荷重を増加させることができる。

【００２１】一方、図３（ｄ）に示すように、上面側からシリコン層１０１，酸化シリコン層１０２及びシリコン層１０３からなるＳＯＩウエハ１００の下面に、接点間ギャップを形成するため、例えば、シリコン酸化膜をマスクとするＴＭＡＨによるウェットエッチングを行い、図３（ｅ）に示すように、下方側に突出する支持部２１と凸部２４とを形成する。そして、図３（ｆ）に示すように、絶縁膜２７を設けた後、可動接点２８を形成する。

【００２２】次いで、図３（ｇ）に示すように、前記ベース１０に前記ＳＯＩウエハ１００を陽極接合で接合一体化する。そして、図３（ｈ）に示すように、ＳＯＩウエハ１００の上面をＴＭＡＨ，ＫＯＨ等のアルカリエッチング液で酸化膜である酸化シリコン層１０２までエッチングして薄くする。さらに、フッ素系エッチング液で前記酸化シリコン層１０２を除去して、図３（ｉ）に示すようにシリコン層１０３すなわち可動電極２５を露出させる。そして、ＲＩＥ等を用いたドライエッチングで型抜きエッチングを行い、切欠部２６ａ及びスリット２６ｂ，２６ｃを形成して第１，第２梁部２２，２３を切り出し、可動基板２０が完成する。

【００２３】なお、ベース１０はガラス基板１１ａに限らず、少なくとも上面を絶縁膜で被覆した単結晶シリコン基板で形成してもよい。

【００２４】次に、前記構成からなる静電マイクロリレーの動作について図４の模式図を参照して説明する。

【００２５】両電極１２，２５間に電圧を印加せず、静電引力を発生させていない状態では、図４（ａ）に示すように、第１梁部２２は弾性変形せず、支持部２１から水平に延びた状態を維持するので、可動基板２０は固定基板１０と所定間隔で対向する。したがって、可動接点２８は、両固定接点１３，１４から開離している。

【００２６】ここで、両電極１２，２５間に電圧を印加して静電引力を発生させると、第１梁部２２が弾性変形し、可動基板２０が固定基板１０に接近する。これにより、まず、凸部２４が固定基板１０に当接する。前記静電引力は、図５に示すように、電極間距離が小さくに従って増加する傾向にある。そして、両基板１０，２０が凸部２４が固定基板１０に当接するまで接近すると、両電極１２，２５間に作用する静電引力は急激に増大するように設定している。したがって、可動基板２０は、凸部２４の周囲をも部分的に弾性変形させることにより、可動電極２５を固定電極１２に吸着される。この結果、図４（ｂ）に示すように、可動接点２８が固定接点１３，１４に閉成する。そして、可動接点２８が固定接点１３，１４に当接した後は、図４（ｃ）に示すように、第１梁部２２に加えて第２梁部２３が撓み、可動電極２５が固定電極１２を被覆する絶縁膜１５に吸着される。したがって、可動接点２８は、その周囲の可動電極２５が固定電極１２に吸着されることにより、第２梁部２３

を介して固定接点１３，１４に押し付けられる。このため、片当たりが発生せず、接触信頼性が向上する。

【００２７】このとき、第１、第２梁部２２，２３が可動電極２５を上方に引張る力、絶縁膜１５を介した可動電極２５と固定電極１２との間の静電引力、絶縁膜１５の表面からの抗力をそれぞれF_{s1}，F_{s2}，F_e，F_nとすると下記の関係があり、第１、第２薄板梁部２２，２３のバネ係数、可動電極２５と固定電極１２との初期ギャップ、接点の厚み等を設計することによりF_n，F_{s1}を小さくし、F_{s2}すなわち接触荷重の（理想モデルからの）低下を抑えることが可能である。

【００２８】

【数１】

$$F_e = F_{s1} + F_{s2} + F_n$$

【００２９】その後、両電極１２，２５間の印加電圧を除去すると、第１、第２梁部２２，２３の弾性力のみならず、凸部２４近傍の変形に伴う弾性力をも接点開離力として作用させることができる。したがって、たとえ接点間に粘着や溶着等が発生していても、確実に開離させることが可能となる。そして、接点開離後、可動基板２０は第１梁部２２の弾性力によって元の位置に復帰する。

【００３０】このように、前記実施形態では、凸部２４を形成したので、接点開離力を大幅に増大させることができ、印加電圧除去時の可動基板２０の動作をスムーズに行わせることが可能となる。

【００３１】また、可動基板２０全体をシリコンウェハ単体で形成すると共に、左右点対称，断面線対称となるように形成されている。このため、可動電極２５に反りや捩りが生じにくい。したがって、動作不能，動作特性のバラツキを効果的に防止できると共に、円滑な動作特性を確保可能となる。

【００３２】本発明に係る静電マイクロリレーは、図８に示す従来例とほぼ同様な図６に示す構成としてもよい。

【００３３】すなわち、この静電マイクロリレーでは、支持部３１が固定基板３０の上面に設けた矩形枠体で構成されている。可動基板４０は、支持部３１の内縁から連結部３２に片持ち支持されている。可動基板４０の下面には絶縁膜４１が形成され、その自由端側には可動接点４２が設けられている。また、可動接点４２と連結部３２の間には凸部４３が形成され、可動接点４２が固定接点３３に閉成する前に固定基板３０に当接するようになっている。

【００３４】なお、前記実施形態では、可動電極２５，４０を平坦形状としたが、その上面に凹所を形成して薄肉としてもよい。これにより、所望の剛性を確保しつつ軽量であっても、動作速度，復帰速度をより一層向上させることが可能となる。

【００３５】また、前記可動電極２５，４０を梁部２２，２３よりも厚肉として剛性を大きくしてもよい。これにより、静電引力のすべてを可動電極２５に対する吸引力とすることができ、静電引力を効率良く第１梁部２２又は連結部３２の変形に利用可能となる。

【００３６】なお、前記実施形態では、可動基板を４本の第１梁部２２又は１本の連結部３２で支持するようにしたが、３本あるいは２本の第１梁部２２で支持するようにしてもよい。これにより、面積効率の良い静電マイクロリレーを得ることが可能となる。具体的に、可動基板２５を２本の第１梁部２２で支持するものを図７に示す。このものでは、第１梁部２２を２本とした以外は図１に示すものと同様な構成となっている。

【００３７】

【発明の効果】以上の説明から明らかなように、本発明に係る静電マイクロリレーによれば、両基板のうち、少なくともいずれか一方に凸部を形成するようにしたので、簡単な構成で大型化することなく、安価に接点開離力を増大させることができる。

【００３８】また、凸部を、支持部と接点との間の少なくとも１箇所に設けるようにしたので、接点が接近する前に、確実に凸部を基板に当接させることができる。

【００３９】特に、凸部を、該凸部を設けた基板とは反対側の基板に当接した際、そのとき電極間に生じる静電引力により、前記凸部の近傍で可動基板を弾性変形させて接点を閉成可能とする寸法以下の高さとしたので、静電引力を効果的に利用することが可能となる。

【００４０】また、可動基板を支持部から延びる複数の梁部を介して均等に支持すると共に、凸部を各梁部に対応して均等に設けるようにしたので、可動基板の安定した動作を得ることができる。

【図面の簡単な説明】

【図１】　本実施形態に係る静電マイクロリレーの平面図（ａ）及びその断面図（ｂ）である。

【図２】　図１の静電マイクロリレーの分解斜視図である。

【図３】　図１の製作プロセスを示す断面図である。

【図４】　図１の静電マイクロリレーの動作状態を示す模式図である。

【図５】　電極間距離と静電引力との関係を示すグラフである。

【図６】　他の実施形態に係る静電マイクロリレーの平面図（ａ）及びその断面図（ｂ）である。

【図７】　さらに他の実施形態に係る静電マイクロリレーの平面図である。

【図８】　従来例に係る静電マイクロリレーの部分正面図（ａ）及び駆動時の片あたり状態を示す正面図（ｂ）である。

【符号の説明】

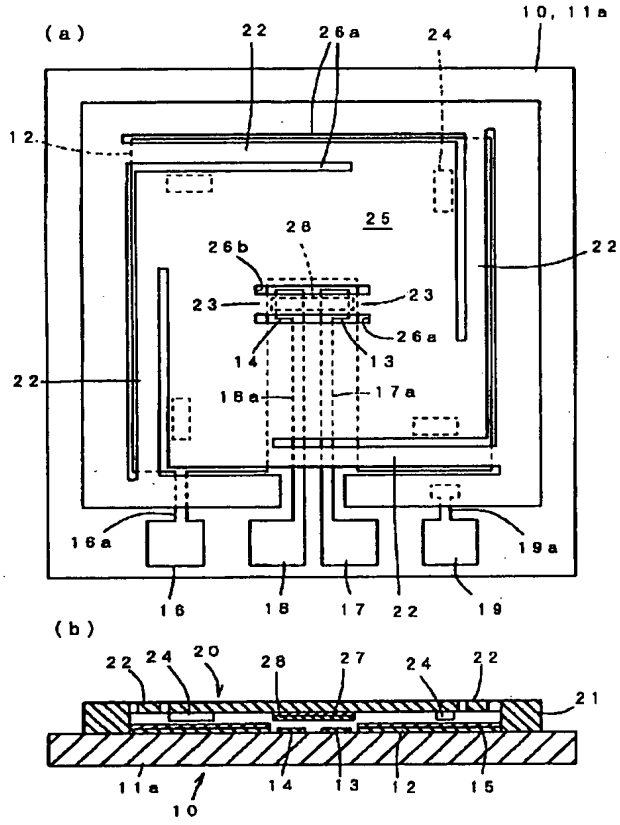
１０…固定基板

１１ａ…ガラス基板

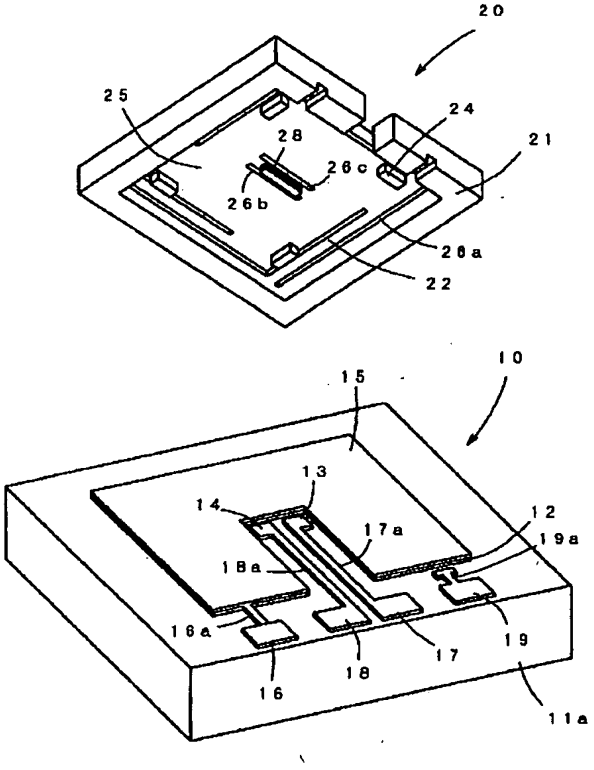
7 8

１２…固定電極
１３，１４…固定接点
２０…可動基板
２１…支持部
２２…第１梁部
２３…第２梁部
＊２４…凸部
２５…可動電極
２６ａ…切欠部
２６ｂ，２６ｃ…スリット
２７…絶縁膜
＊２８…可動接点

【図１】



【図２】



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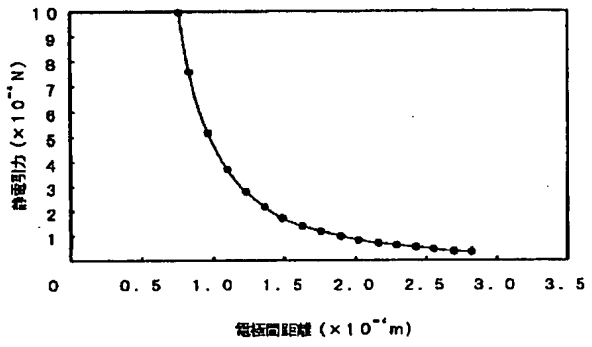

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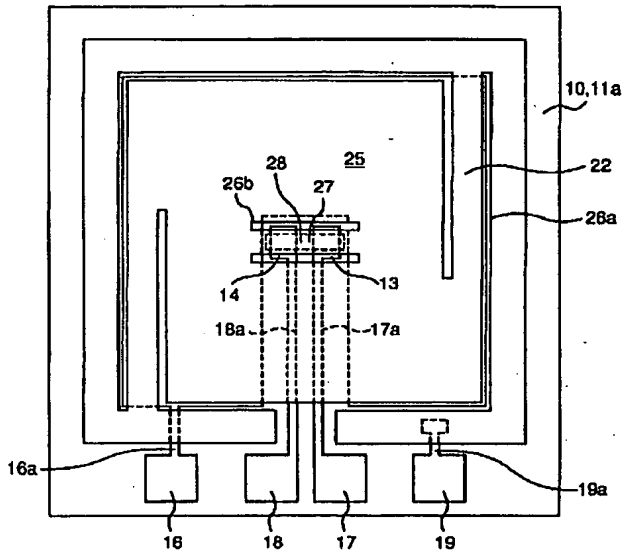

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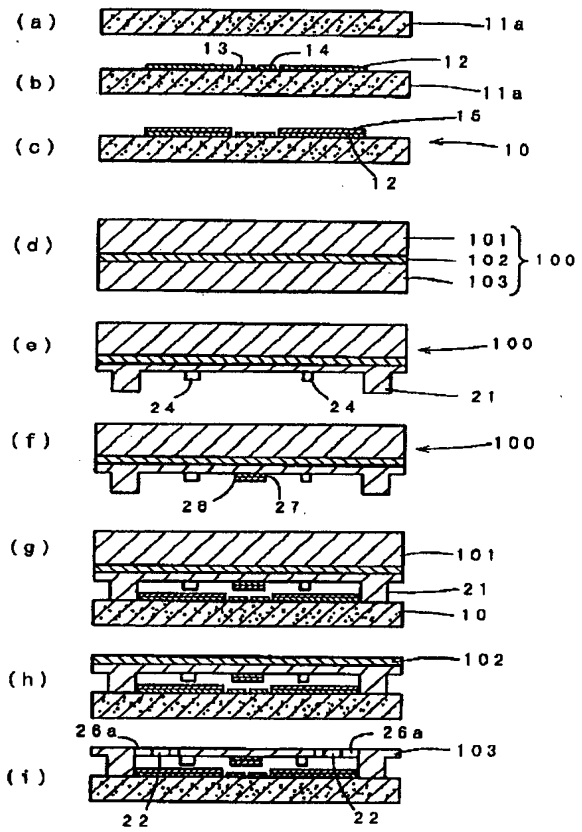
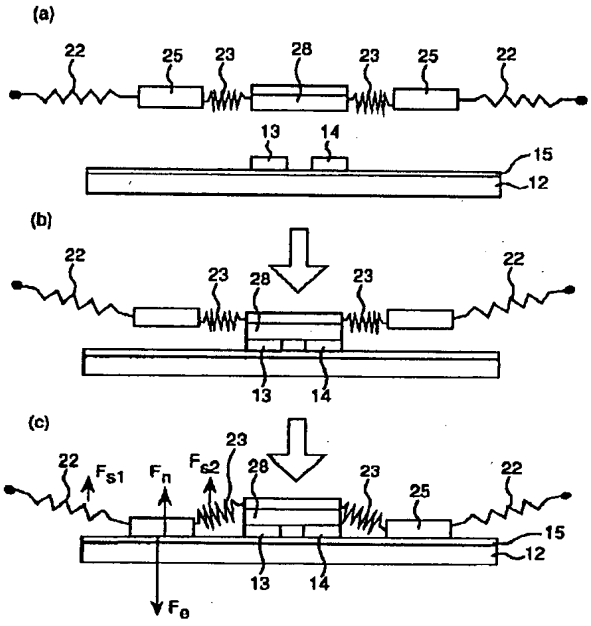
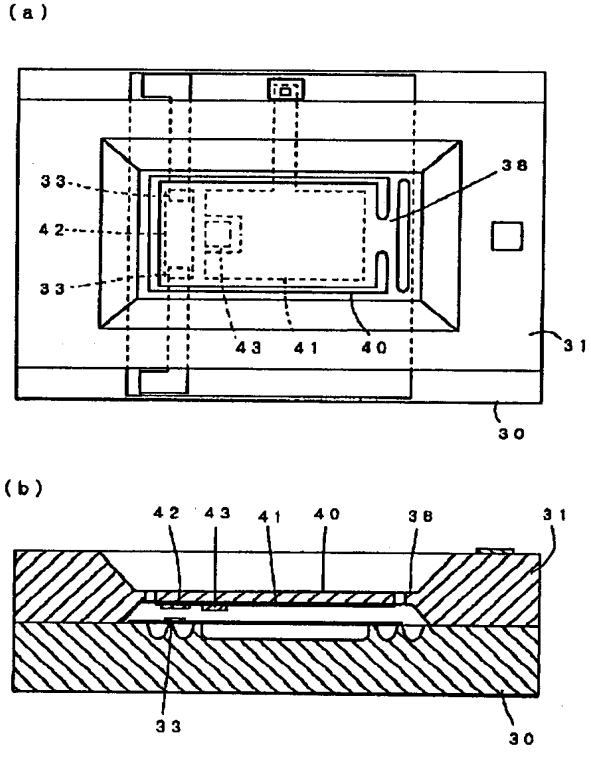

(a)
11a
13
14
(b)
12
11a
15
(c)
10
12
(d)
101
102
103
100
(e)
100
24
24
21
(f)
100
28
27
(g)
101
21
10
(h)
102
26a
26a
(i)
103
22
22

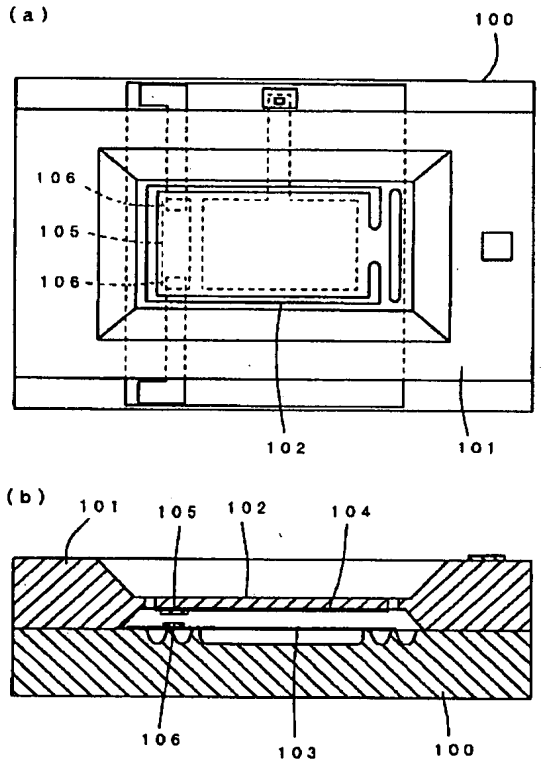
【図４】


(a)
22
25
23
28
23
25
22
13
14
15
12
(b)
22
23
28
23
22
13
14
(c)
22
Fs1
Fn
Fs2
23
28
23
25
22
15
12
13
14
Fe

【図６】


(a)
33
42
33
38
43
41
40
31
30
(b)
42
43
41
40
38
31
33
30

【図８】



PATENT ABSTRACTS OF JAPAN

(11)Publication number : 2000-164104
(43)Date of publication of application : 16.06.2000

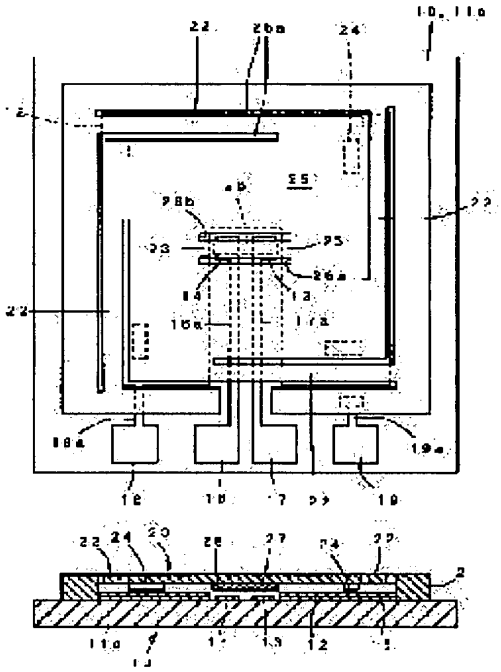
(51)Int.Cl. H01H 59/00

(21)Application number : 10-335725
(22)Date of filing : 26.11.1998

(71)Applicant : OMRON CORP
(72)Inventor : SEKI TOMONORI

(54) ELECTROSTATIC MICRORELAY

(57)Abstract:
PROBLEM TO BE SOLVED: To improve contact point opening performance without enlarging an electrostatic microrelay by forming a projecting part at least in either one of a fixed base board and a movable base board, and allowing the projecting part to abut to the other base board before closing a contact point.
SOLUTION: A movable base board 20 is arranged on an upper surface of a fixed base board 10 composed of a glass substrate 11a. A projecting part 24 is formed on a connecting part under surface of a first beam part 22 of the movable base board 20 and a movable electrode 25. When the movable base board 20 deflects by electrostatic attraction, the projecting part 24 surely abuts to the fixed base board 10 before closing a contact point. When allowing the projecting part 24 to abut to the fixed base board 10, a distance between a fixed electrode 12 and the movable electrode 25 is formed so as to become 1/3 or less of an interval between the separated fixed base board 10 and the movable base board 20. The electrostatic attraction suddenly increases when the projecting part 24 abuts to the fixed base board 10, and the movable electrode 25 can be reliably attracted to the fixed electrode 12. The projecting part 24 is arranged on the fixed base board 10 side or may be arranged on both base boards 10, 20.



LEGAL STATUS

[Date of request for examination]	03.07.2002
[Date of sending the examiner's decision of rejection]	
[Kind of final disposal of application other than the examiner's decision of rejection or application converted registration]	
[Date of final disposal for application]	
[Patent number]	3796988
[Date of registration]	28.04.2006
[Number of appeal against examiner's decision	

of rejection]
[Date of requesting appeal against examiner's decision of rejection]
[Date of extinction of right]
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CLAIMS

[Claim(s)]
[Claim 1] By carrying out opposite arrangement of the movable substrate at intervals of predetermined through a supporter at a fixed substrate, impressing an electrical potential difference between the fixed electrode of a fixed substrate, and the movable electrode of a movable substrate, generating electrostatic attraction, and driving a movable substrate In the electrostatic micro relay which closes the traveling contact of a movable substrate to the stationary contact of a fixed substrate The electrostatic micro relay characterized by making it contact the substrate of another side where heights are formed in either at least among said both substrates, and said heights remain after the drive of a movable substrate, and before contact closing.
[Claim 2] Said heights are electrostatic micro relays according to claim 1 characterized by preparing in at least one between said supporters and contacts.
[Claim 3] For the substrate which prepared these heights, said heights are electrostatic micro relays according to claim 1 or 2 characterized by being the height below the dimension which is made to carry out elastic deformation of the movable substrate near said heights, and enables closing of a contact with the electrostatic attraction then produced in inter-electrode when the substrate of the opposite side is contacted.
[Claim 4] An electrostatic micro relay given in claim 1 characterized by preparing said heights equally corresponding to each **** while supporting said movable substrate equally through two or more beam sections prolonged from a supporter thru/or any 1 term of 3.

[Translation done.]

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DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[Field of the Invention] This invention relates to an electrostatic micro relay.
[0002]
[Description of the Prior Art] There is a thing of a configuration of being conventionally shown in drawing 8 as an electrostatic micro relay (refer to publication-number 5-No. 2976 official report).

[0003] In this electrostatic micro relay, elastic support of the movable substrate 102 was carried out inside the supporter 101 of the shape of a frame prepared in the top face of the fixed substrate 100, and the fixed electrode 103 formed in the top face of the fixed substrate 100 and the movable electrode 104 formed in the inferior surface of tongue of the movable substrate 102 have countered. And by impressing an electrical potential difference between said two electrodes 103,104, generating electrostatic attraction, and attracting a movable electrode 104 to a fixed electrode 103, the movable substrate 102 is sagged and a traveling contact 105 is closed to a stationary contact 106.
[0004]
[Problem(s) to be Solved by the Invention] However, in said electrostatic micro relay, since adhesion, joining, etc. occur at the time of contact closing, the elastic return force must be enlarged so that a contact can be opened certainly. For this reason, it will be necessary to increase the electrostatic attraction generated between two electrodes, and driver voltage (electrical potential difference impressed to inter-electrode) and the electrode surface product which counters must be enlarged, the gap dimension of an electrode must be made small, or it must be coped with using an electret etc. Consequently, complication of increase of occupied volume, the fall of contact pressure-proofing, structure, and a processing process and a cost rise were invited.
[0005] Then, this invention is easy structure, and it makes it a technical problem to offer the electrostatic micro relay excellent in the contact opening nature which it can be cheap and can be manufactured easily, without causing enlargement.
[0006]
[Means for Solving the Problem] This invention carries out opposite arrangement of the movable substrate at intervals of predetermined through a supporter as said The means for solving a technical problem at a fixed substrate. By impressing an electrical potential difference between the fixed electrode of a fixed substrate, and the movable electrode of a movable substrate, generating electrostatic attraction, and driving a movable substrate Heights are formed in either at least among said both substrates, and it is made to contact the substrate of another side which remains said heights after the drive of a movable substrate, and before contact closing in the electrostatic micro relay which closes the traveling contact of a movable substrate to the stationary contact of a fixed substrate.
[0007] If an electrical potential difference is impressed between two electrodes and electrostatic attraction is generated by this configuration, on the whole, the part prolonged from that supporter will carry out elastic deformation of the movable substrate, and the heights prepared in one of substrates will contact the substrate of another side which remains. Thereby, a movable electrode approaches a fixed electrode and electrostatic attraction increases. Therefore, since elastic deformation is partially carried out near the heights and a fixed electrode is adsorbed in a movable electrode, a traveling contact closes a movable substrate to a stationary contact.
[0008] Then, if the applied voltage between two electrodes is removed, electrostatic attraction will disappear and the elastic force accompanying the partial deformation generated when not only the elastic force generated by bending of the whole part prolonged from a supporter but heights contacted a substrate will act as contact opening force. And if heights estrange from a substrate, a movable substrate will return to the original opposite location according to the elastic force generated by bending of the whole.
[0009] What is necessary is just to prepare said heights in at least one between said supporters and traveling contacts.

[0010] With the substrate which prepared these heights, when said heights contact the substrate of the opposite side, they should just be taken as the height below the dimension which is made to carry out elastic deformation of the movable substrate near said heights, and enables closing of a contact with the electrostatic attraction then produced in inter-electrode. For example, what is necessary is just to determine the height of heights that the inter-electrode distance in the time of heights contacting a substrate will become 1/3 or less [which was estranged / of substrate spacing]. Trouble is not caused to closing actuation of a contact by the existence of heights established by this in order to increase contact opening force.
[0011] While supporting said movable substrate equally through two or more beam sections prolonged from a supporter, when said heights are equally prepared corresponding to each ****, it is desirable at the point that either before and after heights contact a substrate can operate a movable substrate smoothly.
[0012]
[Embodiment of the Invention] Hereafter, the operation gestalt concerning this invention is explained according to an accompanying drawing.
[0013] Drawing 1 and drawing 2 show the electrostatic micro relay concerning this operation gestalt. This electrostatic micro relay forms the movable substrate 20 in the top face of the fixed substrate 10 which consists of glass substrate 11a.
[0014] A fixed electrode 12 and stationary contacts 13 and 14 are formed in the top face of glass substrate 11a at said fixed substrate 10. The front face of a fixed electrode 12 is covered with the insulator layer 15. Said fixed electrode 12 and stationary contacts 13 and 14 are connected to the connection pad 16, and 17 and 18 through printed-circuit 16a, and 17a and 18a, respectively.
[0015] Moreover, said movable substrate 20 supports a movable electrode 25 equally in the four 1st beam sections 22 which extend in the side from the top-face edge of a supporter 21 established in the top face of said base 10. Heights 24 are formed in the connection partial inferior surface of tongue of the 1st beam section 22 and a movable electrode 25, respectively. And if the movable substrate 20 bends with electrostatic attraction, before a contact closes, heights 24 will surely contact the fixed substrate 10. Moreover, at the time of the contact to the fixed substrate 10, heights 24 are formed so that the distance of two electrodes 12 and 25 may become 1/3 or less [of spacing of the estranged fixed substrate 10 and the movable substrate 20]. When heights 24 contact the fixed substrate 10 by this, electrostatic attraction becomes large rapidly, and it is possible to make a movable electrode 25 stick to a fixed electrode 12 certainly irrespective of existence of heights 24.
[0016] In addition, although said heights 24 were formed in the movable substrate 20, it may prepare in the fixed substrate 10 side, or you may make it prepare them in both the substrates 10 and 20. Moreover, you may make it prepare two or more places of said heights 24 between contacts 13, 14, and 28 and a supporter 21.
[0017] Said supporter 21 is connected to the connection pad 19 through printed-circuit 19a prepared in the top face of the fixed substrate 10. The 2nd beam section 23 is formed in the center of the slits 26b and 26c of a pair at said movable electrode 25. The traveling contact 28 is formed in the center of an inferior surface of tongue of the 2nd beam section 23 through the insulator layer 27. The traveling contact 28 has countered said stationary contacts 13 and 14 possible [attachment and detachment].
[0018] Then, the manufacture approach of the electrostatic micro relay which consists of said configuration is explained.
[0019] First, as shown in drawing 3 (b), a fixed electrode 12 and stationary contacts 13 and 14 are formed in glass substrate 11a, such as Pyrex shown in drawing 3 (a). Moreover, printed circuits 16a, 17a, 18a, and 19a and the connection pads 16, 17, 18, and 19 are formed in coincidence, respectively. And the base 10 shown in drawing 3 (c) is completed by forming an insulator layer 15 in said fixed electrode 12.
[0020] In addition, if the silicon oxide of specific inductive capacity 3-4 or the silicon nitride of specific inductive capacity 7-8 is used as said insulator layer 15, big electrostatic attraction is obtained and a contact load can be made to increase.

[0021] On the other hand, as shown in drawing 3 (d), in order to form the gap between contacts in the inferior surface of tongue of the SOI wafer 100 which consists of the silicon layer 101, a silicon oxide layer 102, and a silicon layer 103 from a top-face side, wet etching by TMAH which uses silicon oxide as a mask is performed, and as shown in drawing 3 (e), the supporter 21 and heights 24 which project in a lower part side are formed. And as shown in drawing 3 (f), after forming an insulator layer 27, a traveling contact 28 is formed.
[0022] Subsequently, as shown in drawing 3 (g), the junction unification of said SOI wafer 100 is carried out by anode plate junction at said base 10. And as shown in drawing 3 (h), with alkali etching liquid, such as TMAH and KOH, the top face of the SOI wafer 100 is etched to the silicon oxide layer 102 which is an oxide film, and is made thin. Furthermore, a fluorine system etching reagent removes said silicon oxide layer 102, and as shown in drawing 3 (i), the silicon layer 103 25, i.e., a movable electrode, is exposed. And mold omission etching is performed by the dry etching using RIE etc., notch 26a and Slits 26b and 26c are formed, the 1st and 2nd beam sections 22 and 23 are started, and the movable substrate 20 is completed.
[0023] In addition, the base 10 may form at least not only by glass substrate 11a but by the single crystal silicon substrate which covered the top face with the insulator layer.
[0024] Next, actuation of the electrostatic micro relay which consists of said configuration is explained with reference to the mimetic diagram of drawing 4 .
[0025] Since the condition of having not carried out elastic deformation of the 1st beam section 22, but having extended horizontally from the supporter 21 is maintained as an electrical potential difference is not impressed between two electrodes 12 and 25 but it is shown in drawing 4 (a) in the condition of not generating electrostatic attraction, the movable substrate 20 counters at intervals of the fixed substrate 10 and predetermined. Therefore, the traveling contact 28 is opened from both the stationary contacts 13 and 14.
[0026] Here, if an electrical potential difference is impressed between two electrodes 12 and 25 and electrostatic attraction is generated, the 1st beam section 22 will carry out elastic deformation, and the movable substrate 20 will approach the fixed substrate 10. Thereby, heights 24 contact the fixed substrate 10 first. Said electrostatic attraction is in the inclination which inter-electrode distance boils small, therefore increases, as shown in drawing 5 . And if both the substrates 10 and 20 approach until heights 24 contact the fixed substrate 10, two electrodes 12 and the electrostatic attraction which acts among 25 will be set up so that it may increase rapidly. Therefore, when the movable substrate 20 carries out elastic deformation also of the perimeter of heights 24 partially, a movable electrode 25 is adsorbed by the fixed electrode 12. Consequently, as shown in drawing 4 (b), a traveling contact 28 closes to stationary contacts 13 and 14. And after a traveling contact 28 contacts stationary contacts 13 and 14, as shown in drawing 4 (c), in addition to the 1st beam section 22, the 2nd beam section 23 bends, and the insulator layer 15 with which a movable electrode 25 covers a fixed electrode 12 is adsorbed. Therefore, when a traveling contact 28 is adsorbed by the fixed electrode 12 in the movable electrode 25 of the perimeter, it is pushed against stationary contacts 13 and 14 through the 2nd beam section 23. For this reason, per piece does not occur but contact dependability improves.
[0027] The force in which the 1st and 2nd beam sections 22 and 23 pull a movable electrode 25 up at this time, The electrostatic attraction between the movable electrodes 25 and fixed electrodes 12 through an insulator layer 15, When reaction from the front face of an insulator layer 15 is set to Fs1, Fs2, Fe, and Fn, respectively, there is the following relation. It is possible by designing the spring multiplier of 1st and 2nd sheet metal **** 22 and 23, the initial gap of a movable electrode 25 and a fixed electrode 12, the thickness of a contact, etc. to make Fn and Fs1 small and to suppress the fall (from an ideal model) of Fs2, i.e., a contact load.
[0028]
[Equation 1]
$F_e = F_{s1} + F_{s2} + F_n$

[0029] Then, if the applied voltage between two electrodes 12 and 25 is removed, not only the elastic force of the 1st and 2nd beam sections 22 and 23 but the elastic force accompanying

about 24 heights deformation can be made to act as contact opening force. Therefore, even if adhesion, joining, etc. have occurred between contacts, it will become possible to make it open certainly. And the movable substrate 20 returns to the original location according to the elastic force of the 1st beam section 22 after contact opening.
[0030] Thus, with said operation gestalt, since heights 24 were formed, contact opening force can be increased sharply and it becomes possible to operate the movable substrate 20 at the time of applied-voltage removal smoothly.
[0031] Moreover, while forming the movable substrate 20 whole with a silicon wafer simple substance, it is formed so that it may become symmetrical with right-and-left point symmetry and a profile line. For this reason, it is hard to produce curvature and **** in a movable electrode 25. Therefore, while being able to prevent effectively the variation in impossible of operation and an operating characteristic, it becomes securable [a smooth operating characteristic].
[0032] The electrostatic micro relay concerning this invention is good also as a configuration shown in the almost same drawing 6 as the conventional example shown in drawing 8 .
[0033] That is, the supporter 31 is constituted from this electrostatic micro relay by the rectangle frame prepared in the top face of the fixed substrate 30. The cantilevered suspension of the movable substrate 40 is carried out to the connection section 32 from the common-law marriage of a supporter 31. An insulator layer 41 is formed in the inferior surface of tongue of the movable substrate 40, and the traveling contact 42 is formed in the free one end. Moreover, heights 43 are formed between a traveling contact 42 and the connection section 32, and before a traveling contact 42 closes to a stationary contact 33, the fixed substrate 30 is contacted.
[0034] In addition, although movable electrodes 25 and 40 were made into the flat configuration with said operation gestalt, a hollow is formed in the top face and it is good also as thin meat. Thereby, even if lightweight [securing desired rigidity], it becomes possible to raise a working speed and a return rate further.
[0035] Moreover, rigidity may be enlarged as more nearly heavy-gage in said movable electrodes 25 and 40 than the beam sections 22 and 23. Thereby, all the electrostatic attraction can be made into the suction force over a movable electrode 25, and it becomes it is efficient and available to deformation of the 1st beam section 22 or the connection section 32 about electrostatic attraction.
[0036] In addition, although the movable substrate was supported in the four 1st beam sections 22 or the one connection section 32, you may make it support in 3 or the two 1st beam sections 22 in said operation gestalt. It enables this to obtain the electrostatic micro relay with sufficient area effectiveness. Concretely, what supports the movable substrate 25 in the two 1st beam sections 22 is shown in drawing 7 . In this thing, it has the same composition as what is shown in drawing 1 except having made the 1st beam section 22 into two.
[0037]
[Effect of the Invention] Contact opening force can be increased cheaply, without enlarging with an easy configuration according to the electrostatic micro relay concerning this invention, since heights were formed in either at least among both substrates so that clearly from the above explanation.
[0038] Moreover, before a contact approaches, heights can be made to contact a substrate certainly, since heights were prepared in at least one between a supporter and a contact.
[0039] It becomes possible to use electrostatic attraction effectively especially, since it considered as the height below the dimension which is made to carry out elastic deformation of the movable substrate near said heights, and enables closing of a contact with the electrostatic attraction then produced in inter-electrode when the substrate of the opposite side is contacted in heights with the substrate which prepared these heights.
[0040] Moreover, since heights were equally prepared corresponding to each **** while supporting the movable substrate equally through two or more beam sections prolonged from a supporter, the actuation by which the movable substrate was stabilized can be obtained.

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DESCRIPTION OF DRAWINGS

[Brief Description of the Drawings]
[Drawing 1] They are the top view (a) of the electrostatic micro relay concerning this operation gestalt, and its sectional view (b).
[Drawing 2] It is the decomposition perspective view of an electrostatic micro relay of drawing 1 .
[Drawing 3] It is the sectional view showing the manufacture process of drawing 1 .
[Drawing 4] It is the mimetic diagram showing the operating state of an electrostatic micro relay of drawing 1 .
[Drawing 5] It is the graph which shows the relation between inter-electrode distance and electrostatic attraction.
[Drawing 6] They are the top view (a) of the electrostatic micro relay concerning other operation gestalten, and its sectional view (b).
[Drawing 7] It is the top view of the electrostatic micro relay concerning the operation gestalt of further others.
[Drawing 8] It is the front view (b) showing a condition per the partial front view (a) of the electrostatic micro relay concerning the conventional example, and piece at the time of a drive.
[Description of Notations]
10 -- Fixed substrate
11a -- Glass substrate
12 -- Fixed electrode
13 14 -- Stationary contact
20 -- Movable substrate
21 -- Supporter
22 -- The 1st beam section
23 -- The 2nd beam section
24 -- Heights
25 -- Movable electrode
26a -- Notch
26b, 26c -- Slit
27 -- Insulator layer
28 -- Traveling contact

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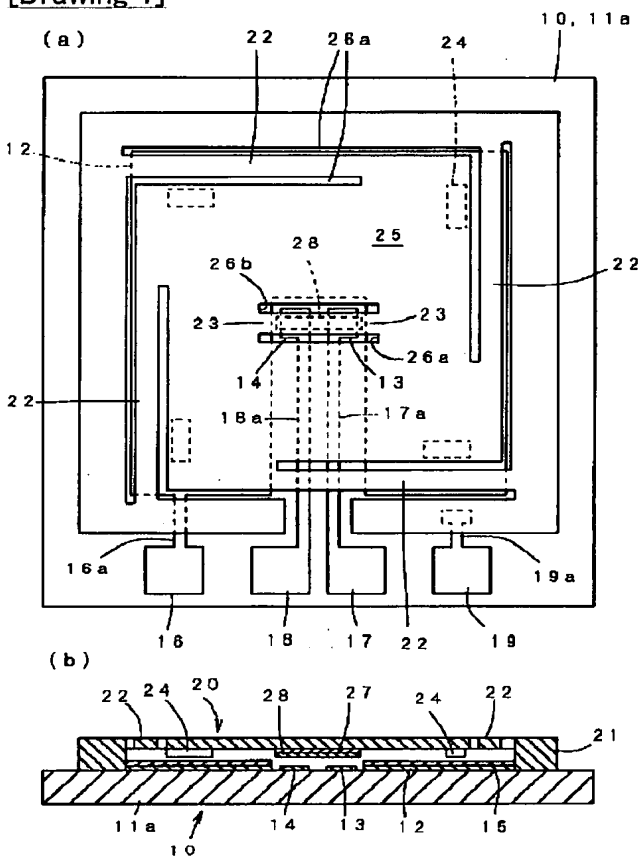
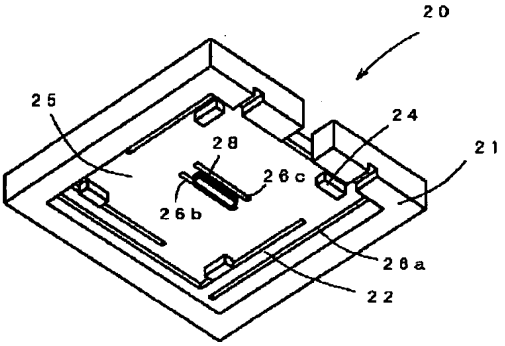
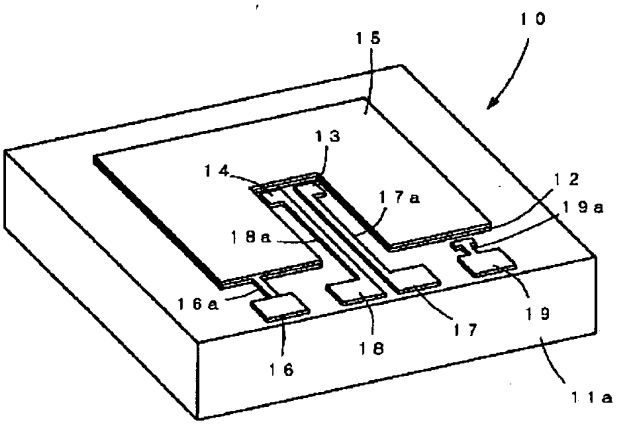
DRAWINGS

[Drawing 1]

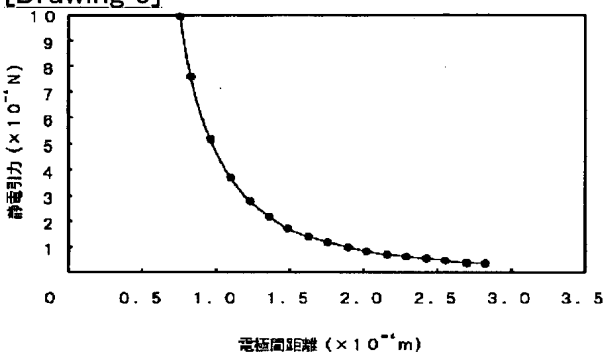


[Drawing 2]

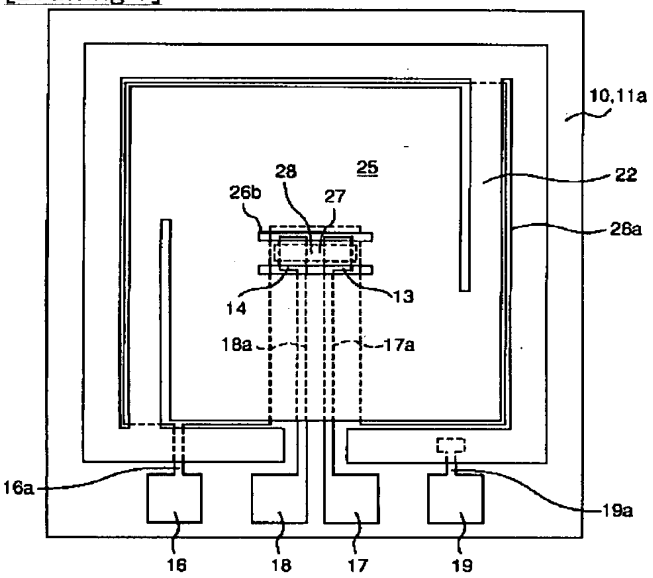




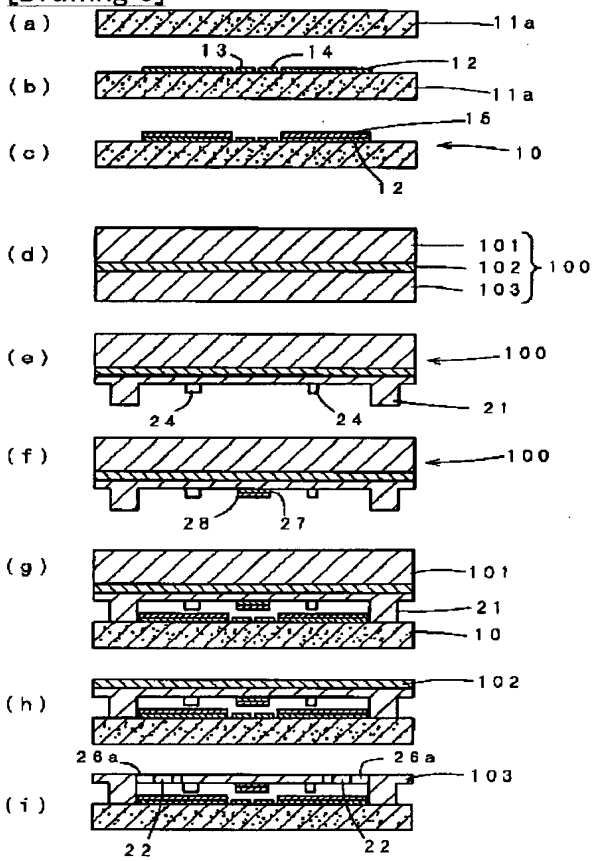
[Drawing 5]



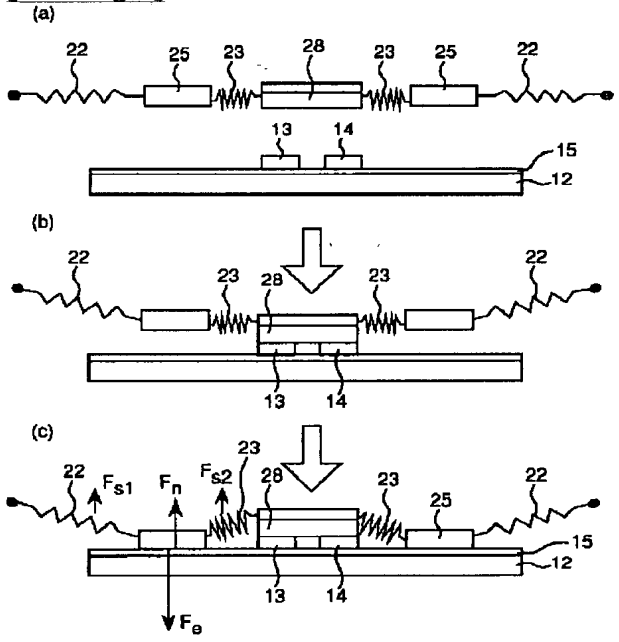
[Drawing 7]



[Drawing 3]

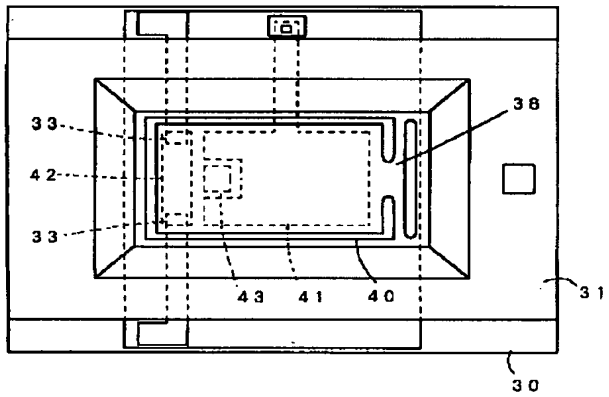


[Drawing 4]

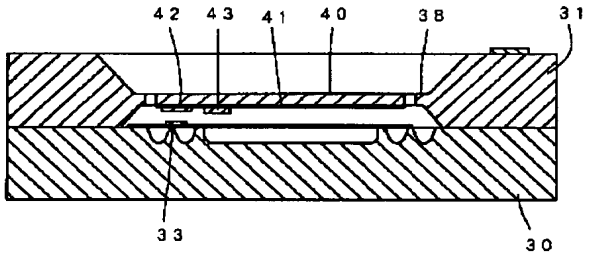


[Drawing 6]

(a)

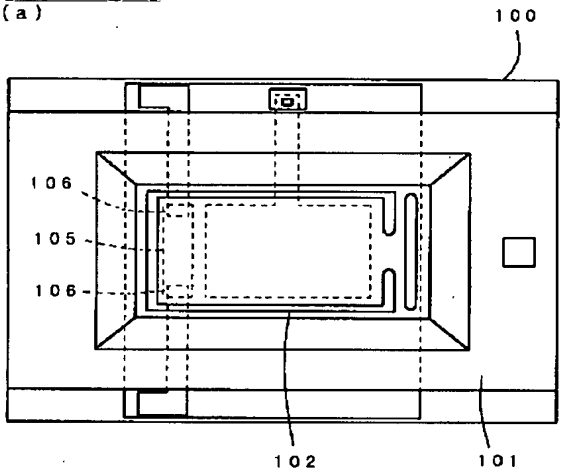


(b)

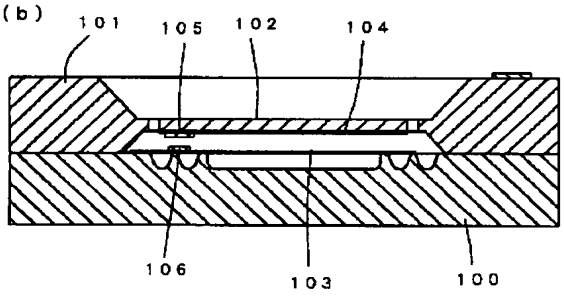


[Drawing 8]

(a)



(b)



[Translation done.]